

FLYBRELLA: A Device to Attract and Kill House Flies

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ABSTRACT FLYBRELLA is a lightweight inexpensive trap that can be suspended like an upside-down umbrella in prominent locations where house flies, *Musca domestica* L., rest. It consists of a solid, cylindrical backbone to which is attached a perforated transparent tube, or baffle, with a commercial sugar/toxicant strip affixed inside. Centered directly beneath the tube and also attached to the backbone is a 10-cm-diameter inverted opaque plastic cone. House flies readily enter the tube, feed on the fast-acting toxicant, and then fall directly down the tube where they are collected in and concealed by the cone. The cone may be emptied easily through a capped opening in the bottom. In paired indoor tests, the efficacy of the commercial sugar/toxicant strip was increased significantly by the individual addition of several other attractant materials. Variants of the original design were tested, including a more efficient design featuring two concentric tubes with offset perforations. The toxicant strip may be easily removed and/or replaced when desired.

KEY WORDS house fly, trap, bait, attractant, toxicant

The house fly, *Musca domestica* L., can be a serious pest in restaurants, supermarkets, and discount stores, and other retail outlets where food is sold and/or prepared. House flies enter structures through open doorways, and readily locate and congregate in food preparation areas. Prevention of fly entry is particularly difficult because many modern store designs typically include wide automatic customer entrance doors as well as freight doors that may remain open for extended periods.

Methods for house fly control inside commercial establishments are extremely limited. Application of pesticide fogs or surface residuals is rarely permitted, and granular sugar/toxicant scatter baits cannot be used (Mitchell et al. 1975). Sticky fly-paper strips are visually unappealing, tend to drip and leave sticky residues in warm areas; thus, they cannot be used near food preparation surfaces. Hence, businesses generally rely on UV light traps containing glue boards that are typically wall mounted at the periphery of food preparation areas. These traps are used even though the relative attraction of flies to UV light and food items has not been well documented.

Many indoor fly aggregation areas are in exposed interior locations that have no windows. We have observed that house flies in open bakery areas tend to rest on water lines and electrical cables that hang vertically from false ceilings to furnish water and power, respectively, to equipment on the floor. We are aware of no trap or control technique that is available for management of house flies in this situation.

We considered commercial attractants and toxicant baits that might be appropriate for such indoor situations. The house fly pheromone, (Z)-9-tricosene (Carlson et al. 1971), has been formulated with toxicants to attract and kill house flies at outdoor farm locations (Carlson and Beroza 1973, Mitchell et al. 1975, Carlson and Leibold 1981). However, the only toxicant device containing (Z)-9-tricosene that is registered for use around food preparation areas is the QuikStrike strip (QS, Sandoz Agro, Des Plaines, IL). QuikStrike is a long-lasting commercial product consisting of a paper panel (8 by 36 cm) coated on both sides with sugar and nithiazine ([²H-1,3-thiazine, tetrahydro-2-(nitromethylene)], 1% [AI], Wellmark, Bensenville, IL), that is a very fast-acting toxicant with very low mammalian toxicity. A perforated plastic sheet encloses the toxicant strip to meet the EPA requirement that the toxicant cannot be touched or handled during deployment or disposal. QS also is registered for use in animal confinement facilities and can be extremely effective for fly control (J.A.H., unpublished data). Golden Malrin (GM) is registered for indoor use in poultry rearing facilities and not for use inside or around homes where the product is accessible to children and animals. BlueStreak (BS) may not be used around or inside homes or any other places where children are likely to be present. Residential use is prohibited, but it may be used on walkways in caged layer houses.

Our preliminary tests were performed in the laboratory by exposing laboratory-reared house flies to candidate chemical attractants applied on sticky cards (7.5 by 12.5 cm) (Hogsette et al. 1993) that were attached to vertical surfaces. When sets of four cards treated with individual and mixtures of several chem-

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ical attractants were exposed simultaneously in dose-response tests, numeric differences between treated and control cards were slight and only 40% of the released flies were captured on the sticky cards. However, when these same attractants were tested in vertically oriented perforated clear plastic tubing made from plastic drink bottles, house flies readily entered the tubing to locate the attractants. As a result of these earlier studies, we then developed a transparent, semi-enclosed trap containing a fast-acting toxicant for indoor deployment. This report documents the development of such a trap and the evaluation of attractants that were added to improve its effectiveness.

Methods and Materials

House Flies. Mixed sex house flies were obtained from a pesticide-resistant colony (Cradson P) reared and maintained at USDA (Hogsette 1992). Flies were transferred from colony cages (45 by 45 by 45 cm) to small release cages (Hogsette and Koehler 1992) with an UV light. Numbers for release were estimated by weight without anesthesia. Flies in release cages were starved for 1 h before being released into the test rooms (3 by 4 m). Tests were initiated within 2–4 h after flies were released. In concurrent tests performed in different rooms, treatments were rotated among rooms between repeats according to a predetermined schedule.

FLYBRELLA (FB). The backbone of the trap was constructed from a plastic rod (0.8-cm polyethylene) with two hooks (or pegs) inserted into the backbone, and a curved handle at the top (Fig. 1). Clear plastic tubing made of polyethylene terephthalate (PETG; 4.3 cm in diameter by 36 cm in height by 0.9 mm in thickness) was fabricated as a baffle and perforated with 30 evenly spaced holes of 1-cm diameter in four vertical columns. Single baffles were hung on the two hooks of the backbone. A 10-cm-diameter cone was cut from the top of a 2-liter PETG soda bottle, painted yellow, inverted, and attached at the bottom of the backbone with a wire tie. The cone was suspended directly below the baffle and retained the original screw cap. Baits for FB were made from strips (3.4 by 36 cm) of QS cut from the commercial product, but the accompanying glass vials of commercial attractant were not used. One strip was suspended inside the baffle from a small-diameter wire that was fitted into small holes at the top of the baffle. Alternative baits were made by sprinkling ≈ 10 g of Golden Malrin [GM sugar-based fly bait, 1.0% methomyl, 0.025% (Z)-9-tricosene, Starbar, Dallas, TX] or Blue Streak [BS sugar-based fly bait, 1.0% methomyl, 0.025% (Z)-9-tricosene, Farnam Co., Omaha, NE] onto 3.4- by 36-cm cardboard strips covered with sticky clear adhesive on plastic film (Olson Products Inc., Medina, OH). These were suspended individually inside the baffles for competitive tests. Cardboard strips of the same size, with the same adhesive but without any bait, were used as untreated controls.

FLYBRELLA 2 (FB2). FB2 consisted of a second smaller diameter baffle perforated as described above with 21 holes and inserted inside the larger baffle so that the holes were mismatched, to increase retention

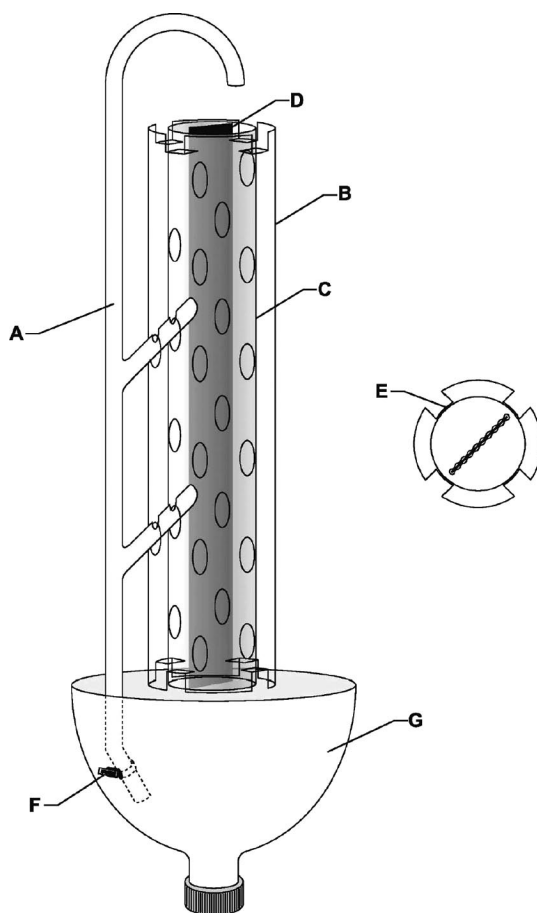


Fig. 1. Flybrella 2. (A) Backbone support. (B) Baffle. (C) Inner baffle. (D) Toxicant strip. (E) Top view of tabs separating baffles. (F) Plastic wire tie. (G) Plastic cone.

of house flies. The smaller diameter baffle was constructed of clear butyrate tubing (2.6 cm in diameter by 36 cm, Consolidated Plastics Co., Twinsburg, OH) in which narrower QS strips (2.0 by 36 cm, no attractant) were suspended. Tabs were cut 6 mm in depth and bent into the inner baffles to provide a concentric space of at least 5 mm between the baffle walls. The double baffle assembly was hung on two hooks of the backbone as described above.

Tests of FB without Additional Attractant. In test 1, two FB were suspended 1 m from the floor in an empty windowless test room (3 by 4 m) 1 m apart, and ≈ 100 house flies were released. No food or water was provided. A GM strip with no other attractive material was deployed in one FB, and a cardboard strip similar in size but without adhesive or bait was used inside the baffle as the untreated control in the other FB. At 1, 3, and 20 h after release of flies, the number of dead flies was counted in the FB cone plus those found within 0.6 m of the FB on the floor. The test was replicated six times. In test 2, an FB containing one of three toxicant strips (QS, GM, or BS) was suspended individually, 1 m above the floor in one of three win-

dowless test rooms as described above. Again, house flies (≈ 100) were released into each room and provided with ad libitum water. Comparisons were made for kill rates of each of the three baits that were deployed inside the baffle as described previously. Live house flies remaining in each room were removed with a vacuum cleaner before the next replication was started. Toxicant strips were rotated through the three treatment rooms according to a predetermined schedule. The test was replicated six times.

Tests of FB with QS Strip and Attractant Chemicals. Attractants included some that were liquids that were suspended inside the baffle with bent paper clips or were held in open packets. In tests 3–7, FB with QS toxicant plus one of several candidate attractants were evaluated in a paired design with FB having a QS strip only (as a control). FB were suspended 1.3 m from the floor and 1.3 m apart concurrently in three small houses (2.6 by 2.6 m), with 24 h/d light and heat (≈ 20 – 22°C). From 88 to 133 house flies were released without food or water, and dead house flies were counted in the FB cone and directly under the FB in flat collection pans (41 by 55 cm as used in other tests) at 22 h. All released flies had died by this time from lack of water, so the next replication was started immediately after dead flies were removed.

In test 3, the attractant was commercial farm-grade blackstrap molasses soaked onto a medium weight cotton string (36 cm) and allowed to drip for 1 h. The saturated string was suspended inside the baffle of one FB adjacent to the QS strip and replaced after 3 d. Dead flies were counted in and under the cone within a 0.5-m circle. The test was replicated 12 times.

In test 4, the attractant materials included commercial food flavorings: artificial molasses (AM) ($n = 6$), artificial bread ($n = 12$), and artificial pizza (Bush, Boake and Allen, Inc., Chicago, IL) ($n = 6$). A 1-cm square piece of filter paper was treated with 1 μl of a formulation containing 1 or 10% acetone solutions or 100% material equivalent to 10, 100, or 1,000 μg of each attractant, respectively. Each treated filter paper square was suspended inside the baffle of a separate trap next to a QS strip to be compared with a plain QS strip. Treatments were made up fresh daily. Test five consisted of commercial honey distillate (H; Bush, Boake and Allen, Inc.) ($n = 19$) that was tested the same way as in test 4. Test 6 used H (1 g) in a solid, unscented gel carrier (Last Call, IPM Technologies, Portland, OR) ($n = 18$).

In test 7, paired tests of FB with one QS strip each were conducted to determine the effectiveness of AgriSense Muscalure bait formulation (AgriSense, BCS Limited, Treforest Industrial Estate, Pontypridd, United Kingdom). Solid pieces of bait weighing 0.13, 0.30, or 0.40 g were suspended inside the baffle from a wire next to the QS strip. A 20-g donut-shaped cake of water gel (made from 2% sodium alginate solution and 10% calcium carbonate solution) was added to the FB cone and tested together with only the 0.40-g AgriSense dose ($n = 15$).

In test 8, pairwise tests of FB (single baffle) versus FB2 (double baffle) were performed with QS baits (with no additional attractants) in two separate test

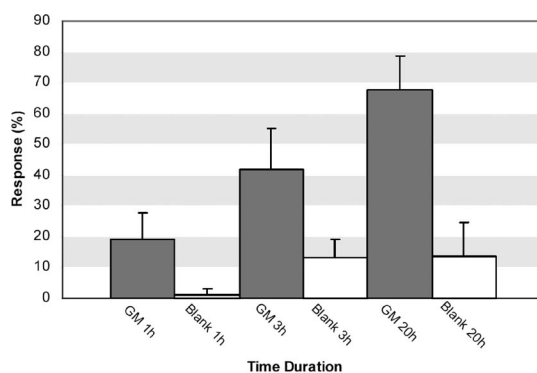


Fig. 2. Test 1. Percentage of response (\pm SD) of house flies to Flybrella with GM versus blank.

rooms to determine which baffle configuration prevented more flies from fluttering out of the trap onto the floor. Data were expressed as percentage of flies in cones and overall percentage of dead flies (% flies in cone + % flies in the collection pan on floor). Test was replicated six times.

In test 9, dissimilar traps were placed together in a closed room (3 by 5 m), to determine comparative efficacy in the removal of 20 released flies. One FB trap plus QS strip (without other attractants) was compared with the FB2 with a double baffle and a toxicant strip consisting of GM sugar bait containing the sex pheromone (Z)-9-tricosene, molasses (3 g) in an open polyethylene packet, and a micro-encapsulated "manure card" containing skatole (5 by 8 cm, Print-A-Scent, Harrison, TN). Test was replicated six times.

Statistical (or Data) Analysis. All data expressed as percentages were subjected to square-root transformation before analyses, but actual values are reported in text and tables. Data were analyzed with PROC GLM by using the model: fly response = attractant + rep + treatment room + trap position, and means were separated with Duncan's multiple range test (SAS Institute 2003). Unless otherwise stated $P < 0.05$. Paired data (treatment and control) were subjected to *t*-test, assuming equal variances (SAS Institute 2003). For some tests, a response ratio was calculated as number of flies killed by treatment/control. Unless otherwise stated, there were no differences between test rooms. Cumulative values for fly mortality between treatments were compared at designated time intervals.

Results

In test 1, most of the released flies were found dead inside the FB traps after 20 h of exposure (Fig. 2). House fly mortality to FB traps with GM bait was 67% after overnight exposure without water compared with 13.7% for FB without any bait. Significant differences in mean percentages of flies killed at each time interval were found as expected, with the FB containing GM bait always killing significantly more flies than the FB containing no toxic bait.

In test 2, numbers of house flies captured in individual baited traps continued to increase during tests

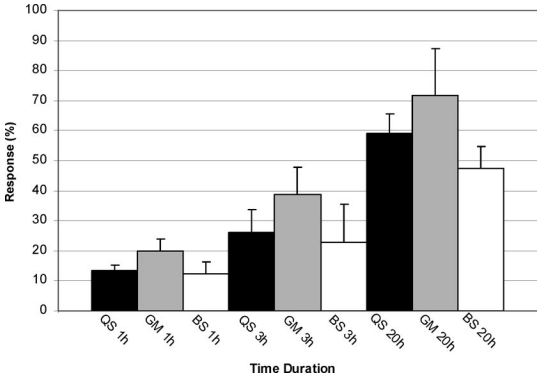


Fig. 3. Test 2. Percentage of response (\pm SD) of house flies to Flybrella with each of three bait/toxicant strips, GM, QS, and BS at three time intervals.

lasting up to 20 h in separate rooms (Fig. 3). Summarized data for GM, QS, and BS showed that GM killed significantly more flies than did the other two baits at all times, with 19.8, 38.6, and 71.7% of flies being killed at 1, 3, and 20 h after release. QS killed fewer flies than GM, followed by BS with significantly fewer (Fig. 3).

In test 3, FB with blackstrap molasses attractant added to plain QS killed an average of 36% of the released house flies compared with just 10% killed by QS alone (Table 1).

Test 4 showed that FB and QS plus artificial molasses killed larger numbers of flies with increasing doses of molasses, but there were no significant differences between doses ($F = 0.73$; $df = 13, 35$; $P > 0.7148$). The same was true for the pizza ($F = 0.86$; $df = 13, 35$; $P > 0.5993$) and the bread ($F = 1.38$; $df = 13, 35$; $P > 0.2461$). Artificial

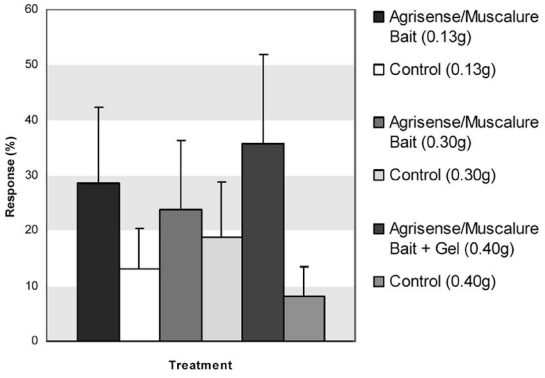


Fig. 4. Test 7. Percentage of response (\pm SD) of house flies to Flybrella with QS versus added AgriSense Muscalure attractant at 0.13, 0.3, and 0.4 g plus water gel.

molasses (at all three doses) plus QS killed more flies than plain QS, but differences were not significant (Table 1). Artificial pizza at all three doses was slightly more attractive than plain QS, but only the 10% dose was significant (Table 1). Only the 10% dose of artificial bread seemed to be slightly attractive (+8.6%), and there was no statistical difference between treatments and controls (Table 1). In test 5, honey distillate at 100% killed fewer flies than the control (Table 1). However, in test 6, the same amount of honey distillate mixed with the carrier gel Last Call was more attractive than plain QS with odorless gel (Table 1). This difference was not significant (Table 1).

In test 7, comparing the three doses of AgriSense bait added to QS, there were no statistical differences in mean numbers of flies killed due to dose (Fig. 4). Differences between treated and control FB were significant at the 0.13- and 0.40-g levels but not at the 0.30-g level (Fig. 4). A significantly ($P < 0.001$) higher percentage of flies (35.5 versus 8.5% in controls) was attracted by the addition of water gel to FB containing the 0.40 g of AgriSense bait (Fig. 4).

In test 8, significantly more flies were retained in the cones of FB2 than FB (Fig. 5). During the six paired tests, 46.1 and 19.1% of the 534 house flies killed were retained by the cones of FB2 and FB, respectively. An average of 2.1 and 5.9 house flies escaped from the FB2 and FB, respectively, before dying, showing a significant difference in retention of flies by the double baffle design. Overall, a significantly larger percentage of released flies (65.4%) was killed by FB2 than by FB (34.6%) demonstrating that the double baffle trap not only retained more flies in its cone but also attracted and killed more flies than did the single baffle trap.

In test 9, the FB2 trap containing GM bait, a manure card, and a molasses sachet killed significantly more flies than FB plus QS alone. FB2 similarly killed more flies than FB at all time intervals. However in each test, significantly more house flies were killed by both traps during the second time interval. Nevertheless, the response rate seemed to be relatively constant at ≈ 0.5 flies per h per trap during the first and second time intervals.

Table 1. Percentage of response (means \pm SE) and test statistics from tests 3 to 6

Test no.	Treatment	Mean	SE	df	<i>t</i>	<i>P</i> > <i>t</i>
3	Blackstrap molasses	35.39	2.70	16	-7.63	<0.0001
	Control	10.05	1.93			
4	AM 1%	26.43	3.06	10	-1.46	0.1759
	Control	19.07	4.02			
	AM 10%	29.51	5.55			
	Control	23.60	4.39			
	AM 100%	34.74	3.96			
4	Control	24.24	3.93	10	-1.88	0.0888
	Bread 1%	25.34	2.53			
	Control	30.00	3.30			
	Bread 10%	26.21	4.60			
	Control	17.61	2.05			
4	Bread 100%	26.93	2.18	10	1.69	0.1224
	Control	34.45	3.89			
	Pizza 1%	34.70	4.42			
	Control	25.48	4.56			
	Pizza 10%	30.87	1.61			
4	Control	22.11	2.18	10	-3.23	0.0090
	Pizza 100%	29.08	6.98			
	Control	27.99	6.46			
	Honey	26.00	2.72			
	Control	31.28	2.91			
5	Honey	26.00	2.72	36	1.33	0.7771
	Control	31.28	2.91			
6	Last Call	37.74	6.06	34	-1.34	0.1883
	Control	28.06	3.90			

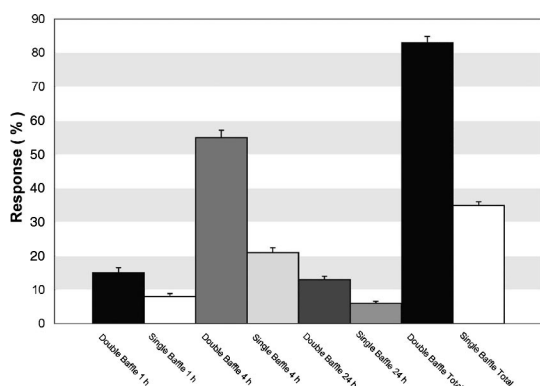


Fig. 5. Test 8. Percentage of response (\pm SD) of house flies to Flybrella with QuikStrike versus double baffle Flybrella with three attractive substances (GM, manure card, and molasses) by using 20 house flies in a study over time.

Discussion

House flies prefer to rest indoors on vertical objects, including strings, ropes, and wires before engaging in food-seeking behavior. We took advantage of this behavior to design the device as an attractant-toxicant device for use indoors with restricted access to the toxicant, including places where house flies rest on hanging electrical wire cables. Moreover, we wanted to attract flies to sugar-based fly bait with attractants, in a trap configuration to which they could readily gain access, ingest and quickly be killed by a semi-enclosed bait, and then fall through the bait enclosure into a collecting device located directly below. The advantageous modification of the trap, as described here, is the arrangement of a double baffle that contains the attractive bait material that enhances the catch. The size of the transparent tube comprising the perforated tube does not seem to be critical, as small tubes (1.8–2.6 cm in diameter) and large tubes (up to 11 cm in diameter; data not shown) that enclosed a toxicant strip worked well. The perforations must be large enough so flies will readily enter (≈ 1 cm), but small enough that they do not leave until they are too intoxicated to do so.

Natural unprocessed molasses and AgriSense Muscature bait were found to be the most attractive in the present tests. Addition of a long-lasting water supply in the form of a gel seemed to increase the fly catch, but this aspect will require further testing for confirmation. As stated on its label, the QS formulation is claimed to be effective until completely consumed by flies, although a scheduled replacement would be recommended at 3 mo. Also, this toxicant remains effective indoors (away from UV light) for several weeks. The toxicants used here were nonvolatile, and the treatments should stay inside the tubing enclosure as described. Flakes of sugar that fell off by physical disturbance during installation seemed to fall straight down into the cone and thus were

retained. The steep sides of the cone tend to retain flies as well but could be supplemented by addition of a slippery or sticky material to the cone to help retain falling flies. We envision that this trap could be useful in superstores, food stores, restaurants, homes, or any indoor location where flies are a problem. The FB could be used to accommodate any attractive bait that may become available in the future.

The baffle containing the toxicant can be replaced in seconds by removing the old tube and hanging the new tube without contacting the toxicant material. There is no power requirement and the device is inexpensive and completely passive. Captured house flies are removed from view by falling into the cone. This feature has a distinct advantage compared with illuminated or electrocuting fly-control devices, where dead flies tend to remain in view on sticky surfaces or may become odorous when electrocuted. We know of no devices or material offered for sale that has the characteristics of the FB. Additional testing of FB needs to be done in more complex facilities, especially those facilities that have competing vertically oriented landing sites.

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